UNIVERSITI PUTRA MALAYSIA

THE COCOA BLACK ANT-MEALYBUGRELATIONSHIP: ARTIFICIAL ESTABLISHMENT OF CATAENOCOCCUS HISPIDUS (HOMOPTERA: PSEUDOCOCCIDAE) ON COCOA

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THE COCOA BLACK ANT-MEALYBUG RELATIONSHIP: ARTIFICIAL ESTABLISHMENT OF *CATAENOCOCCUS HISPIDUS* (HOMOPTERA: PSEUDOCOCCIDAE) ON COCOA

by

Ang Ban Na

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Agricultural Science in the Faculty of Agriculture, Universiti Pertanian Malaysia.

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ARTIFICIAL ESTABLISHMENT OF *CATAENOCOCCUS HISPIDUS*

(HOMOPTERA: PSEUDOCOCCIDAE) ON COCOA

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The cocoa black ant *Dolichoderus thoracicus* (Smith), plays an important role in the control of the cocoa mirid *Helopeltis theobromae* (Miller) in Malaysia. The ant has a mutualistic relationship with a variety of homopterans, the commonest one being the mealybug *Cataenococcus hispidus* (Morrison). Attempts to manipulate *D. thoracicus* are dependent on the ability to manipulate *C. hispidus*. The study carried out was aimed at obtaining information on *C. hispidus* to enable the mealybug to be established more successfully.

A method of estimating the number of individuals in a first instar colony was devised. The relationship between the number of individuals (Y) and the area of the colony (X) in mm^2 is described by the linear equation: $Y=8.55X - 2.98$. The area of colony was measured by using a transparent glass grid.

When using adult female C. hispidus for introduction, it was shown that the optimum time to do so was three days before the ants. It was also found that when the ants were established without the mealybugs, establishment of the former was significantly lower.

Rainfall and natural enemies, mainly coccinellids, neuropterans and slugs, are important mortality factors that seriously hamper establishment of mealybugs. Exposed to rain and natural enemies, the number of nymphs that eventually established on cocoa pods was only four percent of those which received protection from both factors.

The first instar crawlers are the important dispersing stage, in Homoptera. Therefore, studies were conducted on crawler behaviour of C. hispidus. The crawlers show a positive phototactic response and negative geotactic response. There was a strong preference by the crawlers to establish on the artificially scarified surface of pod. Mortality of unfed crawlers was higher at 55±10% relative humidity than at 95±5% relative humidity. When unfed crawlers were kept at 15, 20, 30 and 35 °C, survival was highest at 20 °C.

Ants and mealybugs were introduced onto 100, 50 and 13% of the trees in a cocoa area. It was found that higher introduction densities resulted in more trees being colonised. But, in terms of number of colonised trees per initially infested tree, the lower densities were more efficient.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi sebahagian daripada syarat-syarat untuk Ijazah Master Sains Pertanian.

PERHUBUNGAN SEMUT HITAM KOKO-KOYA: PERTAPAKAN BUATAN *CATAENOCOCCUS HISPIDUS* (HOMOPTERA: PSEUDOCOCCIDAE) DALAM TANAMAN KOKO

oleh

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Semut hitam koko. *Dolichoderus thoracicus* (Smith), memainkan peranan penting di dalam mengawal kepinding nyamuk, *Helopeltis theobromae* (Miller) koko di Malaysia. Semut ini mempunyai perhubungan mutualisma dengan beberapa jenis homopteran, di antara mana yang paling kerap ialah koya *Cataenococcus hispidus* (Morrison). Usaha-usaha manipulasi ke atas semut adalah bergantung kepada kebolehan usaha-usaha manipulasi terhadap koya. Kajian ini dijalankan dengan tujuan untuk memperolehi maklumat-maklumat berkenaan *C. hispidus* agar kegiatan penempatan koya ini boleh diusahakan dengan berjaya.

Satu kaedah untuk menganggarkan bilangan individu di dalam koloni instar pertama telah dirangkakan. Perhubungan diantara bilangan individu (Y) dan luas kawasan koloni (X) dalam mm^2 adalah dijelaskan melalui persamaan linear: Y=8.55X - 2.98. Luas kawasan koloni telah diukur dengan gelas lutsinar bergrid.

Apabila menggunakan dewasa betina C. hispidus untuk memulakan infestasi, telah didapati bahawa masa optimum untuk perlakuan sedemikian supaya pertapakan koya yang maksima diperolehi, ialah tiga hari sebelum semut dimasukkan. Juga telah didapati bahawa apabila semut-semut itu bertapak dengan ketiadaan koya maka adalah didapati pertapakan semut-semut ini berkurangan dengan bererti.

Hujan dan musuh-musuh semulajadi, terutamanya coccinellid, neuroptera and lintah bulan adalah faktor-faktor mortaliti penting yang mana sungguh-sungguh menghalang pertapakan koya. Apabila terdedah kepada hujan dan musuh-musuh semulajadi, bilangan nimfa yang akhirnya bertapak pada lenggai-lenggai buah koko hanya lah empat peratus daripada yang mendapat perlindungan daripada kedua-dua faktor tersebut.

Peringkat instar pertama merupakan peringkat yang utama untuk persebaran bagi Homoptera. Oleh itu, kajian dijalankan terhadap tabiat nimfa instar pertama koya. Mobiliti nimfa ini telah didapati berkurang dengan bererti setelah didedahkan kepada kebuluran. Nimfa instar pertama menunjukkan gerak balas fototaksis positif dan gerak balas geotaksis negatif. Telah didapati nimfa-nimfa amat tertarik untuk bertapak di permukaan parut buatan atas lenggai. Bila disimpan pada kelembapan udara 55±10% dan 95±5% mortaliti nimfa yang kebuluran lebih tinggi pada kelembapan udara 55%. Bila nimfa yang kebuluran tersimpan pada 15, 20, 30 dan 35°C, kemandirian adalah paling tinggi pada 20°C.

Apabila semut dan koya dimasukkan ke 100, 50 dan 13% daripada pokok dalam satu kawasan koko, didapati bahawa kepadatan penempatan yang tinggi menghasilkan lebih banyak pertapakkan pada pokok-pokok. Tetapi dari segi bilangan pokok yang mempunyai pertapakan semut dan koya per bilangan pokok asal yang digunakan untuk penempatan, penempatan pada kepadatan lebih rendah adalah lebih efisyen.

CHAPTER 1

INTRODUCTION

Clausen (1940) noted that ants were the first group of insects to be utilised in an attempt to control insect pest by the biological method. He cited two uses of ants in tropical tree crops by date palm cultivators in Yemen and by citrus growers in southern China. Ants are a group of predators whose predatory values have not been fully investigated (Room, 1975). It has been suggested that where the fauna associated with ants contain important pest species, a reduction in pest damage by manipulation of the dominant ants become possible (Jutsum *et al*., 1981).

The role of the cocoa black ant, *Dolichoderus bituberculatus* (Mayr.) in protecting cocoa trees from *Helopeltis antonii* (Sign.) and *H. theivora* (Waterh.) in Indonesia have been observed since 1904 (Levert, 1940). A similar relationship in Malaysia was reported for *D. bituberculatus* against *H. theivora theobromae* (Miller) (Collingwood, 1977; Azhar, 1984). Some estates in Indonesia practice biological control of *Helopeltis* soon after beneficial effects of the cocoa black ants were realised. One estate in particular, the Siloewak Sawangan Estate effectively controlled *Helopeltis* for over 40 years, in a 1500 ha plantation with the cocoa black ant (Geisberger, 1983). Khoo (1988) pointed out that D. bituberculatus reported in Indonesia and Malaysia is probably D. thoracicus (Smith), because collections of D. bituberculatus in the British Museum did not originate from these two countries. But in this thesis the name D. bituberculatus used by authors before Khoo (1988) would be retained.

In Indonesia D. bituberculatus is associated with the mealybug Planococcus lilacinus (Ckll.) which provides the ant its main food source, the honeydew (Roepke, 1916; Goot, 1917). D. thoracicus in Teluk Intan, Malaysia is associated with the mealybug Cataenococcus hispidus (Morrison), besides other homopterans like scales and aphids. Room (1973) stressed that in order to maintain the numerical superiority of an introduced ant species, its rate of worker production must be kept as high as possible. Therefore it must be ensured that the supply of food is adequate. In most cases it would probably be necessary to introduce the Homoptera tended by the beneficial ants.

It was found that dispersal of P. lilacinus in the field was not effectuated by the cocoa black ant as believed by cocoa planters (Roepke, 1916; Goot, 1917). Dispersal was mainly a function of the mealybugs own movements and wind. Therefore natural dispersal was found to be too slow to achieve a good distribution quickly. Geisberger (1983) concluded that the mealybugs would have to be introduced or a cocoa black ant introduction will fail.

Success in establishment of an introduced Homoptera is dependent upon many factors. It has been found that presence of attendant ants of the Homoptera enhances establishment (Goot, 1917; Cornwell, 1957). Success of an introduction is also dependent upon timing of introduction with regards to growth stage of the host, e.g. flushing or fruiting (Room, 1973). In homopterans the mobile nymphs which are the principle dispersive stage faces many hazards before they settle to feed. For example, in the scale Aulacaspis tegalensis (Zhnt.) it was found that extreme temperature, low humidity, rain and lack of suitable feeding sites were the major mortality factor for dispersing crawlers (Greathead, 1972). Propensity of crawlers to commence feeding may also be influenced by light (Moran and Cobby, 1979; Gilreath and Smith, 1987). In the cochineal insect, Dactylopius austrinus (de Lotto) propensity of crawlers to settle was enhanced through subjecting them to an artificial "flight" (Moran et al., 1982).

Therefore before the cocoa black ant-mealybug relationship can be used for biological control of Helopeltis a manipulation technique for both the ant, D. thoracicus and mealybug, C. hispidus needs to developed. Considering the importance of mealybugs to the establishment of the ants, and the many factors that are known to influence establishment of homopterans: this thesis focuses on the manipulation of the mealybugs with the aim of increasing its establishment when introduced.

Studies were undertaken with the following objectives:

1. To develop a method for estimation of number of individuals in mealybug colony.
2. To determine the optimum time to introduce the mealybugs

with respect to that of the ants.

3. Determine the effect of rainfall and natural enemies on the establishment of the mealybugs in the absence of the ants.
4. To study some aspects of crawler behaviour
5. To determine the influence of density of trees in a plot used for introduction of the ants and mealybugs, on the success of the ants and mealybugs in colonising the plot.

CHAPTER 2

LITERATURE REVIEW

This literature review gives a general introduction to the biology of mealybugs, ant-homoptera mutualism and methods that have been employed to artificially establish homopterans. More literature relevant to each experiment are given in the respective sections.

Biology of mealybugs

Mealybugs belong to the family Pseudococcidae of the order Homoptera. The adult females are wingless, more or less degenerate, and are covered with a waxy or powdery coating. The males when present are very much smaller then the females and they do not possess any functional mouth part. Being rather tiny and short-lived, the males are not often observed and the forms that are commonly encounterd are the immature stages and adult females. There are four instars in the females and five in the males (Khoo, 1974; Williams, 1985). Mealybugs may be oviparous, viviparous or ovoviviparous (Williams, 1985). In some species the males are totally absent and various types of parthenogenesis occur along with functional hemaphroditism (McKenzie, 1967). The number of eggs or nymphs that can be produced by one female varies according to mealybug species (McKenzie, 1967). As many as

908 nymphs have been produced per female Dysmicoccus brevipes (Ckll.) (Ito, 1938) and 160-299 eggs per female P. lilacinus (Khoo, 1974). The active newly-hatched or born nymphs are the dispersive stage, being able to crawl from plant to plant or be carried by wind or ants to other plants (Khoo, 1974). C. hispidus is viviparous and its biology has been studied by Ang (1988).

ANT ASSOCIATION

Ants as a group are well known mutualists with honeydew-producing Homoptera (Nixon, 1951; Way, 1963; Carroll and Janzen, 1973). In Pseudococcidae the degree of dependence on the ants may vary from strong and almost necessary associations to weak casual seasonal relationships (McKenzie, 1967).

Benefits to ants

Honeydew as source of food. The obvious benefit the ants derive from the homopterans is the acquisition of honeydew as a rich and easily accessible food (Nixon, 1951). In nutritional value, honeydew is more complete then might be expected (McKenzie, 1967). Way (1963) compiled evidence that honeydew may contain sugars, free amino acids and amides, proteins, minerals and B-vitamins. Not all ants forage for honeydew but those that do can at times be the most numerous (Samways, et al., 1982). An example of this was observed by Grant and Moran (1986) in undisturbed woodland savanna, where the dominant ants were almost exclusively honeydew-dependent. It has been suggested that